4.0 ENVIRONMENTAL QUALITY AND THE OPTIMAL CONTROL OF MARKET FAILURE

If the assumptions which underlie the economic model of a perfectly competitive market were universally satisfied in all actual markets for goods and services, all impacts upon the natural environment which might be produced by activities performed in these markets would be appropriately taken into account in the decision making of each individual who participates in any of these markets. However, these assumptions are seldom, if ever, completely satisfied in any actual market. In fact, substantial deviations from full compliance with these assumptions are observed in many markets due to the existence of externalities, public goods, or increasing returns to scale in those markets.

This chapter both describes the problems which arise in the attainment of economic efficiency and the attainment of the most socially desirable allocation of resources when each of these types of market. failure prevails in any particular market and identifies and evaluates the effectiveness of the various public policies which might be employed to resolve these problems in specific situations. Thus, Section 4.1 discusses the nature and the potential resolution of environmental problems attributable to externalities; Section 4.2 contains an analogous treatment of the environmental problems associated with public goods; and Section 4.3 develops a similar analysis of the environmental problems arising from increasing returns to scale. Finally, Section 4.4 presents some general conclusions concerning the manner in which the most socially desirable public policy for the control of any particular market failure can be selected for implementation.

4.1 Externalities

Externalities exist whenever the production or consumption opportunities of individual members of society are directly affected by resource allocation decisions of other society members -- decisions over which the externally affected individuals have no control. To be economically relevant, these external effects must not be attributable solely to the changes in the equilibrium set of market prices which occur as the economy responds to changes in supply and demand conditions. Indeed, these adjustments of equilibrium prices constitute the

primary mechanism through which the market mechanism rations goods and services among alternative users and uses. Finally, the external effects must not result from the performance of malicious actions by the external decision makers. Rather, they must be produced only incidentally by these individuals as they pursue legitimate activities.

Externalities which satisfy these conditions can, and frequently do, prevent the market mechanism from attaining an economically efficient allocation of resources. Specifically, whenever those individuals whose actions generate relevant externalities fail to consider the implications of these external effects in their decision making, it is likely that the resource allocation which is achieved at equilibrium will not be Pareto optimal and, hence, that it will be theoretically possible to specify an infinite number of reallocations of resources which will increase the welfare of at least one member of society without decreasing the welfare of any other member of society. For example, if a firm, in conjunction with the production of its desired output, legally generates smoke which adversely affects the health and welfare of all individuals who reside in the neighborhood of the firm and if the firm fails to incorporate the external costs which it imposes upon its neighbors into its production (and smoke generation) decisions, the firm's equilibrium level of smoke generation generally will exceed the economically efficient level. When this situation prevails, economic efficiency will be enhanced if the firm reduces its generation of smoke to that level at which the cost which it will incur in performing any additional pollution abatement exceeds the gains which are obtained by its neighbors from that additional abatement and if the cost of the abatement which is performed is financed exclusively from the gains which are obtained by the firm's neighbors as a result of this reduction in smoke generation. This financing strategy guarantees that no member of society -- including the smoke generating firm -- will experience a lower level of welfare when smoke generation is curtailed than he obtains when no abatement is performed. Moreover, unless the cost which is incurred by the firm in performing the reduction in smoke generation is precisely equal to the total gains which are obtained by all of the firm's neighbors from this abatement, this financing strategy will not be unique. Rather, it will be possible to produce this increase in economic efficiency with an infinite number of alternative financing strategies which are differentiated only by the relative magnitudes of the net gains which are obtained by the various members of society.

Thus, as this example illustrates, when relevant externalities prevail it is generally possible to identify the direction in which the equilibrium allocation of resources will deviate from the economically efficient allocation of resources, to specify the manner in which resources should be reallocated to attain the economically efficient allocation, and to describe the method by which these modifications should be financed to promote Pareto optimality. However, the recognition and resolution of externality problems also requires both the identification of those market situations in which the externalities which arise can be expected to prevent the market mechanism from attaining economic efficiency and the isolation of techniques which can be employed to induce or require those individuals who are involved in these relevant externality situations to modify their behavior in a manner which is consistent with the attainment of economic efficiency. The resolution of these two issues is the objective of the remainder of this section.

4.1.1 The Possibility of Resolution by Negotiation

To appreciate the possibility of a negotiated resolution of an externality situation, it is necessary to recognize the reciprocal nature of any externality situation. This principle is described particularly well by Coase, who states:

> "The traditional approach has tended to obscure the nature of the choice that has to be made. The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is wrong. We are dealing with a problem of a reciprocal nature. To avoid the harm to B would inflict harm on A. The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A? The problem is to avoid the more serious harm."*

The validity of this principle can be demonstrated easily within the context of the preceding smoke generation example, where it is observed that the unrestricted generation of smoke by the firm both

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*Coase (19), pp. 1-2.

permits the earning of additional profits by the firm and imposes external costs upon the firm's neighbors, while restriction of the firm's generation of smoke both provides gains to the firm's neighbors and imposes smoke control costs upon the firm. Thus, it can be concluded that, in any externality situation, the external effect is caused by both the resource owner who generates the effect and the resource owner who receives it. Consequently, if the optimal allocation of resources is to be attained, it is desirable that both of these resource owners should take account of the external effect in making their resource allocation decisions. In principle, this objective can be attained if an individual who desires to modify the behavior of another individual who is generating an externality engages in trade with that other individual which moves both of them to preferred positions where no additional mutually agreeable trades are available and, hence, Pareto optimal equilibrium prevails.

However, before exchange can occur, it is necessary to establish an assignment of property rights in the externality situation. Thus, in the smoke generation example, it must be established either that the firm possesses the right to generate any quantity of smoke which it determines to be desirable (as has been implicitly assumed in the example) or that the firm's neighbors possess the right to an environment which contains at most a specified quantity of smoke (possibly zero). Yet, after an assignment of property rights has been clearly specified, it can be demonstrated that, if these property rights are transferable* and rigidly enforced and if there are no costs associated with the negotiation and enforcement of transactions, any particular assignment of property rights will produce an economically efficient allocation of resources. Specifically, when these conditions are satisfied, the stipulated assignment of property rights will provide an incentive to one of the two parties who are involved in the externality situation to attempt to change the extent to which external effects are generated by offering inducements to the other party to modify his behavior. Thus, at the extremes, if the resource owner who produces an external effect (e.g., the smoke generating firm) is declared to be

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*Property rights with respect to liability for damages are transferable if the government enforces liability rules only upon appeal by one of the parties who are involved in the externality situation. This enforcement policy introduces the possibility of exchange between these parties.

completely liable for the damages caused by this external effect, he will be motivated to pay an indemnity to the resource owner who receives the external effect (e.g., the firm's neighbors) to secure that resource owner's acquiescence to the production of additional output; while, conversely, if the resource owner who produces an external effect is declared to have no liability for the damages caused by this external effects the resource owner who receives the external effect will be motivated to pay a bribe to the externality-producing resource owner to induce that resource owner to reduce his production. In either case, whenever the resource owner who produces the external effect decides to increase his production, he incurs a cost in the form of either an increased indemnity payment to or a foregone bribe payment from the resource owner who receives the effect. Similarly, whenever the resource owner who receives the external effect decides to decrease the extent to which he absorbs this effect, he incurs a cost in the form of either a foregone indemnity payment from or an increased bribe payment to the resource owner who produces the effect. Consequently, whenever either of these parties makes his resource allocation decisions, he appropriately incorporates the full social cost of his activities into his decision-making process. The inevitable result of this procedure is the attainment of an economically efficient allocation of resources.

It can also be demonstrated that, since the marginal cost associated with any particular increase in the production of an external effect is unaffected by the assignment of different systems of property rights, the same economically efficient allocation of resources will be attained regardless of the particular system of property rights which is adopted, so long as the differences in the distributions of wealth which are associated with the various systems of property rights have no effect upon demand patterns. Thus, in summary, this analysis asserts that if the income elasticity of demand is zero in all markets (including the market for the external effect) and if the costs of negotiating and enforcing transactions are zero, the market resolution of any externality problem will be both economically efficient and allocatively neutral with respect to the assignment of property rights.*

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*See Coase (19) for a more thorough derivation and analysis of these assertions.

However, several researchers have conclusively demonstrated that the asserted allocative neutrality of alternative assignments of property rights will not prevail when some of the resource owners who are involved in the externality situation are merely consumers,* when the income elasticity of demand for at least some goods in the economy is not zero,** or when the costs of negotiating and enforcing transactions are positive.*** Since one or more of these conditions are extremely likely to exist in any realistic externality situation, it is obviously unreasonable to expect that negotiated resolutions of externality situations will be allocatively neutral with respect to alternative assignments of property rights.

Yet, even under these conditions, each alternative assignment of property rights will generate an economically efficient allocation of resources relative to that assignment of property rights. However, different assignments of property rights usually will generate different economically efficient allocations of resources. More specifically, in any particular externality situation, the production of the externality will be greater if the resource owner who produces the external effect is declared to have no liability for the damages attributable to this external effect than if this individual is declared to be completely liable for these damages. Consequently, in any realistic externality situation, the adoption of a particular assignment of property rights may be virtually equivalent to selecting a particular economically efficient allocation of resources at equilibrium.

Moreover, since positive transactions costs inhibit exchange, the disparity between the allocations of resources which prevail at equilibrium under different assignments of property rights in any externality situation will increase as transactions costs increase. In particular, as the externality situation becomes more complex and as the number of resource owners who are involved in this situation increases, transactions costs can be expected to increase and, hence, deviations from allocative neutrality are likely to expand. In fact, it is conceivable that in some externality situations transactions costs

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*Dolbear (39), pp. 95-97 and p. 102 and Mishan (77), pp. 61-66 and pp. 83-84.

**Samuels (97), pp. 6-12 and Weld (114), p. 609.

***Randall (88), pp. 43-44 and Samuels (97), pp. 19-20. For a more detailed discussion of all of these qualifications of the assertion of allocative neutrality, see Sections 2.1.6 and 2.1.9 of this report.

may be so high that movements away from the initial allocation of resources which is specified by the prevailing system of property rights may be impossible.

Recognizing this possibility, Demsetz* has asserted that the absence of an observable market for an externality may constitute an economically efficient outcome since, when this situation exists, the transactions costs which must be incurred to establish a market for this externality must exceed the benefits which will be obtained by society if this market is established. While this assertion is unambiguously true whenever the same level of transactions costs must be incurred for all of the alternative assignments of property rights which might be adopted in this externality situation, its validity is uncertain if different level of transactions costs are associated with different assignments of property rights.

Thus, as several researchers** have stated and at least one researcher*** has demonstrated empirically, it is fallacious to conclude from an observation that no agreement has been negotiated for the internalization of a particular externality that no agreement can be negotiated for the internalization of this externality. It is frequently possible that the adoption of a different assignment of property rights may permit the negotiation of an agreement for the internalization of the externality which has been unattainable under the initial assignment of property rights. For example, in an externality situation in which a single firm is generating smoke which adversely affects a large number of neighboring property owners, a realignment of property rights from a system in which the smoke generating firm is not liable for the damages which are attributable to his activities to a system in which he is fully liable for these damages is likely to promote the negotiated internalization of some externalities which would not have been internalized under the initial assignment of property rights. Under the initial assignment of property rights, any of the neighboring property owners will receive the same benefit from any reduction in the generation of smoke regardless of the magnitude of his contribution toward defraying the cost of providing this reduction in smoke generation.

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*Demsetz (35), pp. 13-14.

**McKean (70), pp. 625-626; Mishan (77), pp. 70-75; Randall (88), pp. 45-46; and Samuels (97), pp. 21-23.

***Crocker (23).

The net result of the adoption of this individually rational behavior pattern by all of the neighboring property owners obviously will be the provision of an inefficiently low level of smoke abatement. Conversely, under the alternative assignment of property rights, the firm will not confront any equivalent incentive to understate his willingness to pay the.neighboring property owners for the opportunity to emit smoke. Hence, the negotiated internalization of the costs attributable to the external effects associated with smoke generation will be greater under this system of property rights unless each individual neighboring property owner, or a relatively small coalition of these property owners, is permitted to exercise effective veto power over the firm's generation of any quantity of smoke.

Yet, despite the obvious differences in the extent to which negotiation may permit the internalization of externalities under different assignments of property rights, it remains true that the allocation of resources which prevails at equilibrium under each assignment of property rights constitutes an economically efficient allocation of resources relative to that assignment of property rights. However, not all of these efficient allocations of resources will constitute a maximization of net social products. Thus, if the maximization of net social product is desired, society must make a choice among different economically efficient allocations of resources.

Nevertheless, if individual preferences are weighted positively in the determination of the level of net social welfare which is associated with any particular allocation of resources, there appears to be substantial justification in any externality situation to adopt an assignment of property rights which provides to the individuals who are involved in this externality situation an ample opportunity to express these preferences. Moreover, since the observed purchasing behavior of an individual in a market situation is generally acknowledged to be the most reliable available indicator of the economic preferences of that individual, it appears desirable in externality situations to adopt assignments of property rights which will maximize the opportunities of the individuals who are involved in those situations to engage in market exchange which will promote the internalization of the externality. Thus, in the absence of overriding social considerations, it appears desirable to rely upon the negotiated resolution of externality problems in any situation in which voluntary negotiation of the permissible level of the externality is feasible. In particular, voluntary negotiation undoubtedly can be relied upon to generate the highest attainable level of net social product in those externality situations in which one property owner's use of a particular portion of his property for the storage

of compost produces objectionable odors on his neighbor's property or a situation in which one property owner's use of a power mower during particular hours of the day severely disturbs the sleep of residents of adjacent properties.

4.1.2 The Appropriate Nature and Role of Public Policy

As the number of individuals who are affected by any particular externality problem increases, the transaction costs associated with the attainment of a negotiated resolution of this problem also increases and, hence, the economic and social desirability of relying upon voluntary negotiation for the resolution of this problem decreases. In particular, in any situation in which it is discovered that some type of nonmarket mechanism may involve a lower level of transactions costs than is attainable through a negotiated internalization of the externality under any assignment of property rights, it is conceivable that the maximization of net social product may require the introduction of some form of governmental intervention.* Specifically, when the number of individuals who are affected by a particular externality problem becomes so large that the internalization of the externality assumes the nature of a public good for all of these individuals, the economic and social desirability of governmental intervention is virtually assured. This situation undoubtedly pertains to the vast majority to the air and water pollution phenomena which are generally acknowledged to be social problems.

4.1.2.1 Unilateral Taxes and Subsidies

The traditional economic resolution of these large-scale externality problems has its origins in the writings of Pigou,** who asserts that an economically efficient allocation of resources is attained by a society when its national dividend is maximized. Moreover, the national dividend will be maximized when the private marginal net product is equal to the social marginal net product in all uses. Thus, inefficiency exists in every activity in which this equality is not satisfied. To eliminate this inefficiency, Pigou proposes the provision of

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*Demsetz (34), p. 34, and Randall (88), pp. 45-46, concur in this conclusion

**Pigou (85).

incentives which will induce those firms which are generating externalities to produce those levels of output which will maximize the national dividend.

More specifically, Pigou recommends the development of a system of taxes and subsidies which will modify the cost function of an externality-producing firm in a manner which will cause the firm's profit-maximizing output level to correspond to the socially optimal output level. This recommendation generally has been interpreted as a proposal that the price of the output of the firm should be modified to reflect more accurately the social marginal net product through the imposition of specific (per unit) excise taxes and subsidies upon this output. Thus, if the firm is generating an external diseconomy, a specific excise tax should be imposed to induce a reduction in output; while, if the firm is creating an external economy, a specific excise subsidy should be provided to motivate an increase in production.

However, Plott* has demonstrated that, unless the desired output of the firm and the externality are produced in fixed proportions, this procedure is fundamentally incorrect. Instead, the corrective tax or subsidy must be imposed either on the particular output which constitutes the externality (e.g., smoke, noise level, water-borne effluent) or, under certain conditions, on the resource input from which the externality is generated. Moreover, if the corrective tax or subsidy is imposed on the specific output which constitutes the externality, it should be set at a level equal to the sum of the values of the incremental external effects which are incurred by all of the individuals who are involved in the externality situation at the economically efficient rate of production of that output. This requirement is expressed somewhat more succinctly in the following equation:

$$T = \sum_{i=1}^{n} ME_i$$

where T = the optimal tax or subsidy per unit of the externality produced,

*Plott (86).

ME_i = the marginal evaluation of the economically efficient rate of production of the output which constitutes the externality by the i^{th} individual who is involved in the externality situation, and

n = the total number of individuals who are affected by the externality problem.

Observe that if the externality is an external economy for the i^{th} individual, ME_i will be positive; while if the externality is an external diseconomy for the i^{th} individual, ME_i will be negative. Thus, if $\sum_{i=1}^{n} ME_i$ is positive, the externality constitutes an external economy for the society, while if this summation is negative, the externality constitutes an external diseconomy for the society.

To promote economic efficiency in the generation of an external economy, the government should either pay to the firm which generates this externality a specific subsidy equal to T for each unit of the externality which it produces or impose upon this firm a tax equal to T for each unit by which its production of the externality falls short of the economically efficient production rate of this externality. Similarly, to promote economic efficiency in the generation of an external diseconomy, the government should either impose upon the firm which generates this externality a tax equal to (-T) for each unit of the externality which it produces or pay to this firm a subsidy equal to (-T) for each unit by which its production of the externality falls short of the rate of production of the externality which the firm would select in the absence of any governmental intervention. Since, if the firm desires to maximize profits, it will choose to produce any unit of the externality for which the total revenue from production (including subsidies) exceeds the total cost of production (including taxes) and will refrain from producing any unit of the externality for which the total cost of production (including taxes) exceeds the total revenue from production

(including subsidies), these taxation and subsidization policies will, in general, induce the firm to adjust its rate of production to the economically efficient rate.*

However, numerous researchers** have challenged the assertion that both taxes and subsidies constitute equally effective mechanisms for the internalization of either external economies or external diseconomies. In any externality situation the determination of the appropriate total magnitude of a tax or a subsidy requires the comparison of the actual level at which an externality is produced to a specified base level of production of that externality. The development of either an economically efficient taxation mechanism for the internalization of an external diseconomy or an economically efficient subsidy mechanism for the internalization of an external economy is not difficult since no production of the externality constitutes an effective specified base level for either of these mechanisms. However, the development of an economically efficient subsidy mechanism for the internalization of an external diseconomy or an economically efficient taxation mechanism for the internalization of an external economy is likely to be substantially more difficult. In particular, the specified base level of externality production for a subsidy mechanism for the internalization of an external diseconomy must be at least as great as the level which the producer of the external diseconomy would choose to produce in the absence of any internalization of the externality; while the specified base level of externality production for a taxation mechanism for the internalization of an external economy must be precisely equal to the level which would be produced if the externality were completely internalized. To guarantee that these conditions will be satisfied,

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*Goetz and Buchanan (47) and Schall (103) have demonstrated that these standard taxation and subsidization policies generally will not produce an economically efficient allocation of resources in externality situations which incorporate reciprocal externalities among different firms in a single perfectly competitive industry. Similarly, Dolbear (39) has proven that these standard policies generally will not promote economic efficiency in externality situations in which the producer of the externality is a utility maximizing consumer. However, as Hay and McGowan (50) and Dolbear have demonstrated in both of these cases the deficiencies of the standard policies can be remedied by introducing either a lump sum subsidy or a lump sum tax in addition to the standard specific tax or subsidy.

**See Dolbear (39), pp. 100-101 and p. 103; Kamien, Schwartz, and Dolbear (53); Mumey (79); and Tybout (110), pp. 261-262.

the administrative authorities which are responsible for the implementation of these mechanisms must have complete knowledge of the cost constraints and revenue opportunities which confront the producers of the externalities. While it is conceivable that acceptable specified base levels for these mechanisms might be determined initially, it is unlikely that these base levels will be maintained at effective levels as the market conditions facing the externality producers change over time. If, at any time, the cost and revenue conditions confronting the producer of an external diseconomy cause his profit-maximizing production level of this externality to exceed the specified base level, the subsidy mechanism will cease to be effective in inducing the internalization of the external diseconomy. Similarly, if the profit opportunities confronting the producer of an external economy cause his profit-maximizing production level of this externality to deviate in either direction from the specified base level, the taxation mechanism will cease to generate an economically efficient allocation of resources. Once again, to assure that the specified base levels will be adjusted appropriately to avoid these outcomes, it is required that the administrative authorities must have complete knowledge of the profit opportunities of the externality producer. Since the likelihood that these conditions will be satisfied in any realistic situations is extremely low, it is very unlikely that both taxation and subsidization will be equally effective mechanisms to induce the internalization of either external economies or external diseconomies. Rather, it is virtually certain that taxation will be more effective than subsidization in inducing the internalization of external diseconomies; while subsidization will be more effective than taxation in inducing the internalization of external economics.

4.1.2.2 The Desirability of Bi-Lateral Taxes and Subsidies

Although unilateral taxation is generally conceded to be superior to unilateral subsidization for the resolution of external diseconomy problems and unilateral subsidization is generally conceded to be superior to unilateral taxation for the resolution of external economy problems, several researchers* contend that neither of these policies is capable of inducing the complete internalization of externalities

*Buchanan (13), Buchanan and Stubblebine (15), Furuboth and Pejovich (43), and Turvey (109).

because each fails to consider the reciprocal nature of any externality situation. In particular, Buchanan and Stubblebine contend:

> "The important implication to be drawn is that full Pareto equilibrium can never be attained via the imposition of unilaterally imposed taxes and subsidies until all marginal externalities are eliminated. If a tax-subsidy method, rather than "trade" is to be introduced, it should involve bi-lateral taxes (subsidies). Not only must B's behavior be modified so as to insure that he will take the costs externally imposed on A into account, but A's behavior must be modified so as to insure that he will take the costs "internally" imposed on B into account. In such a double tax-subsidy scheme, the necessary Pareto conditions would be readily satisfied."*

For example, if a community adopts a unilateral taxation mechanism for the control of air pollution under which the individuals who are adversely affected by this externality are not paid compensation for the pollution which they absorb at equilibrium, these individuals will fail to recognize the full social cost associated with the imposition of more stringent restrictions upon the generation of air pollution and, hence, will be motivated to seek the adoption of these additional, inefficient restrictions. Consequently, it has been recommended that, to preclude this possibility, all of the parties who are involved in this externality situation should be compelled to recognize the full social cost of their actions through the imposition of a bi-lateral system of taxes and subsidies upon both the emitters and the recipients of the air pollution.

The implementation of this recommendation clearly is substantially more difficult than the implementation of a unilateral tax or subsidy. As explained by Regan:

> "The reciprocal nature of most externalities means that Pigou considerably underestimated the difficulty of finding regulatory (tax-subsidy) schemes which would

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*Buchanan and Stubblebine (15), p. 383.

> guarantee internalization...In general to set up an appropriate tax-subsidy scheme might require as much information on the part of the regulating agency as would be required for centralized decision-making. The market-mechanism-plus-regulation, then, is no certain high road to efficiency.*

However, as Baumol** demonstrates, in those situations in which there are a large number of recipients of an externality (e.g., most air or water pollution situations and many noise pollution situations), the introduction of an internalization mechanism under which these recipients are paid compensation for the external effects which they absorb may be unnecessary. In these situations, the external effect constitutes a public externality and the control of the external effect constitutes a public good. Thus, Baumol asserts:

> "As with all public goods, an increase in one user's consumption does not reduce the available supply to others. Hence, the appropriate price (compensation) to a user of a public good (victim of a public externality) is zero except, of course, for lump sum payments. Thus, perhaps, rather than saying there is no price that will yield an optimal quantity of a public good (externality), it may be more illuminating to say that a double price is required: a nonzero price (tax) to the supplier of the good, and a zero price to the consumer. Of course, no ordinary price can do this job, but a Pigouvian tax, without compensation to those affected by an externality, can indeed do the trick."***

Yet, even this assertion requires qualification. In particular, Mohring and Boyd**** show that, even when there are a large number of recipients of an externality, a unilateral tax or subsidy will unambiguously produce an economically efficient allocation of resources only if the control of the externality constitutes a pure public good for each recipient of this externality (i.e., only if the quantity and quality of

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*Regan (90), pp. 436-437.
**Baumol (4), pp. 309-312.
***Baumol (4), p. 312.
****Mohring and Boyd (78), pp. 352-356.

any modification of the production of the external effect which is obtained by each recipient of this effect is completely unaffected by any action which can be taken by this individual). However, if a recipient of the externality can affect the extent to which he benefits from the control of the externality by changing his location, his scale of operation, or any other decision, the attainment of economic efficiency requires that this recipient must be compelled to recognize the impact that his initiation of any of these actions will have upon the socially optimal activity levels of the producers of the externality. In many instances, compelling this recognition may require the imposition of bi-lateral taxes and subsidies.

For example, if the control of air pollution through the imposition of an unilateral tax upon the emitters of air pollution induces additional individuals to locate in the neighborhood of these emitters, the execution of these locational decisions will increase the marginal damages which are attributable to the prevailing level of air pollution. If the unilateral tax has initially been set at a rate equal to the value of the pollution which will prevail when the socially optimal allocation of resources has been attained, these locational adjustments merely will constitute the mechanism through which the initial economically efficient allocation of resources will be transformed into the socially optimal resource allocation at equilibrium. Excessive locational adjustment will not occur because the unilateral tax will induce the emitters of air pollution to generate the socially optimal level of pollution; while the existence of this level of air pollution will discourage the location of an inefficiently large number of recipients of air pollution in the neighborhood of these emitters.

However, if the unilateral tax has initially been set at a rate equal to the value of the marginal damages which are attributable to the prevailing level of air pollution, the induced movement of additional individuals into the neighborhood of the emitters of air pollution will cause the value of the marginal damages which are attributable to this pollution to exceed the established tax rate and, hence, will cause the economically efficient levels at which these emitters should generate air pollution to become less than the prevailing levels at which they presently are generating pollution. To rectify this deviation from economic efficiency within the context of a unilateral taxation mechanism, the unilateral tax must be increased to a rate equal to the increased value of the marginal damages which are attributable to the prevailing level of air pollution. Moreover, this process of adjusting the unilateral tax rate must be repeated until a particular adjustment of the tax rate

which induces no movement of additional individuals into the neighborhood of the emitters of the pollution is introduced. When this condition is achieved, the prevailing unilateral tax rate will be precisely equal to the value of the marginal damages which are attributable to the prevailing level of air pollution and, consequently, the socially optimal allocation of resources will have been attained.*

Yet, unless the implementation of this adjustment process is perfectly costless, it may be more economically and administratively efficient to induce the recipients of the air pollution to take the consequences of their locational decision into account more directly, possibly by imposing upon each of these recipients a site or franchise tax equal to the decrease in the net social product of emitters of air pollution which will result if that individual carries out his location decision. Thus, a bi-lateral taxation or subsidization mechanism may be required for the attainment of economic efficiency whenever the control of an externality does not constitute a pure public good for all recipients of this external effect.**

Finally, Marchand and Russell*** demonstrate that if the cost functions of the recipients of an external diseconomy are non-separable (i.e., if the magnitude of the external cost attributable to the external diseconomy is affected by the output decisions of the recipients of the externality)****, neither a bi-lateral subsidization mechanism nor a bi-lateral taxation mechanism will generate the optimal allocation of resources which evolves when both the producers and the recipients of the external diseconomy cooperate in the maximization of their joint profits. Rather, the adoption of a subsidization mechanism will result in the production of an inefficiently high level of output by the producers of the external diseconomy and an inefficiently low level of production by the recipients of the externality; while the introduction of a taxation mechanism will induce the production of an inefficiently low level of output by the producers of the external diseconomy and an inefficiently high level of production by the recipients of the externality. Yet, in this same situation, an appropriate unilateral taxation or subsidization mechanism can induce an internalization of the external diseconomy which will produce the optimal allocation of resources. Moreover, an

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*Baumol (4), pp. 314-315.

**Mohring and Boyd (78), pp. 354-356.

***Marchand and Russell (66).

****Formally, a cost function $C(q_1, q_2)$ is non-separable if it cannot be expressed in the form $C(q_1, q_2) = C^1(q_1) + C^2(q_2)$.

appropriate unilateral taxation mechanism can also generate an economically efficient allocation of resources when the cost functions of the recipients of the external diseconomy are separable (i.e., if the magnitude of the external cost which is imposed upon each recipient by the external diseconomy is independent of the level of output which is produced by that recipient).

Consequently, it must be concluded that neither the imposition of unilateral taxes or subsidies nor the imposition of bilateral taxes and/or subsidies constitutes a universally effective technique for the internalization of externalities. Rather, in each externality situation, the appropriate internalization mechanism must be determined on the basis of, at least, such considerations as the cost conditions confronting each recipient of the externality, the number of recipients who are involved in the situation, and the extent to which the control of the externality constitutes a pure public good for each of these recipients.

4.1.2.3 The Problem of Multiple Local Optima

Baumol* demonstrates that the presence of sufficiently strong external diseconomies will modify the production and consumption opportunities of society so extensively that any particular taxation mechanism (e.g., unilateral taxation of emitters of air pollution, bilateral taxation of both emitters and recipients of air pollution, etc.) can attain equilibrium at any one of several different economically efficient allocations of resources. However, only one of these allocations of resources will constitute the socially most desirable allocation which can be produced by that taxation mechanism. Moreover, the determination of this socially most desirable allocation of resources requires not only the identification of those allocations of resources for which the first and second order conditions for the maximization of social welfare are satisfied, but also the determination of the particular element of this set of potentially optimal allocations which actually provides the highest attainable level of social welfare. Consequently, the specification of the socially most desirable allocation of resources requires detailed knowledge of both the incremental social costs and

*Baumol (4), pp. 313-320.

benefits which are attributable to any particular change in the rate of production of an external diseconomy and the total social costs and benefits which are associated with any particular rate of production of this externality. In general, it is impracticable to obtain this detailed knowledge. Thus, although it is conceptually possible to structure virtually any taxation mechanism in a manner which will induce the attainment of any desired allocation of resources at equilibrium, information limitations generally preclude the a priori specification of the precise structure of any particular taxation mechanism which will induce the attainment of the socially most desirable allocation of resources. Moreover, the existence of several locally optimal allocations of resources clearly implies that it is inappropriate to rely upon iterative procedures which systematically adjust the structure of this taxation mechanism to achieve this objective, since it is impossible to guarantee that any adjustment process will produce convergence to the socially most desirable allocation of resources rather than to some locally optimal resource allocation.

In this situation, Baumol recommends that society should specify a set of minimum standards of acceptability and, subsequently, seek to develop a taxation and subsidy mechanism which is capable of attaining these specified standards. Although the application of this recommendation obviously will not normally produce the socially most desirable. allocation of resources, it does have the virtue of guaranteeing the provision of some socially acceptable allocation of resources and, hence, of achieving an improvement in the allocation of resources relative to that allocation which would have prevailed in the absence of governmental intervention. For example, this recommendation might be particularly applicable to the control of water pollution in a region through which several rivers and streams flow. While the specification of a comprehensive taxation mechanism which would induce the socially optimal utilization of each of these water courses undoubtedly would be impracticable, the establishment of a taxation system which achieves a satisfactory level of water quality in each river and stream would be administratively feasible and, probably, socially and economically desirable.

This general approach to the resolution of externality problems is also advocated by Dales*, who asserts that the stringent information

*Dales (25).

requirements of those taxation and subsidization mechanisms which provide for the complete internalization of externalities render these mechanisms impossible to implement. Consequently, he concludes that the best available strategy for the control of an externality consists of the specification of a set of minimum standards of acceptability in the production of this externality, the creation of that quantity of rights to produce this externality which is consistent with these standards, and the establishment of a market in which these rights can be exchanged.

Obviously, the prices which are established for these rights in this market are functionally equivalent to Baumol's taxes and subsidies as incentives for the attainment of the specified standards. Thus, the relative desirability of adopting Dale's exchange strategy rather than Baumol's taxation and subsidization strategy in any particular externality situation can be determined primarily on the basis of a comparison of the feasibility and cost of defining, policing, exchanging, and enforcing rights to produce the external diseconomy with the feasibility and cost of establishing, administering, and enforcing taxes or subsidies applied to this production.

4.1.2.4 Information Requirements

Even in those externality situations in which external diseconomies are not sufficiently strong to cause the existence of several locally optimal allocations of resources within the feasible set of production and consumption opportunities of a society, it is possible that taxation and subsidization mechanisms will constitute unsatisfactory instruments to induce the attainment of the socially most desirable resource allocation. In particular, Davis and Whinston* demonstrate that the implementation of a taxation or subsidization mechanism for the internalization of an externality may impose upon the administrator of this mechanism information requirements which are so demanding as to preclude the adoption of the mechanism. Specifically, they prove that the volume of information which must be collected and analyzed to implement a taxation or subsidization mechanism may be sufficient to permit the administrator of the mechanism to determine directly the optimal resource utilization decision for each of the resource owners who is involved in the externality situation. When this condition arises,

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*Davis and Whinston (31) and Davis and Whinston (32).

the direct specification of the optimal allocation of resources (i.e., the direct governmental regulation of the externality situation) will be at least as tractable as the calculation of the appropriate tax and subsidy schedules.* Moreover, this potential dominance of regulation over taxation and subsidization in the internalization of externalities is likely to prevail even in externality situations in which it is possible to apply an iterative procedure which circumvents most of these information collection and analysis requirements for the determination of appropriate taxes and subsidies,** since the implementation and operation of a procedure of this type is not costless.

Yet, it is also conceivable that, in some instances, both direct governmental regulation and the implementation of taxation and subsidization mechanisms will be less effective than some other internalization mechanism in promoting the attainment of the socially optimal allocation of resources. In particular, Davis and Whinston assert that in many externality situations the optimal public policy might be to permit the merger of the resource owners who are involved in the situation until those external effects which can be internalized have been eliminated and, hence, the "natural unit" for decision-making has been achieved.*** Thus, clearly, the substantial differences in the cost of obtaining relevant information in different externality situations render it impossible to assert that the adoption of any particular internalization mechanism will unambiguously be socially most desirable in all externality situations.

4.1.2.5 Uncertainty

If the development of an internalization mechanism which is capable of inducing the attainment of the socially optimal allocation of resources is to be even theoretically possible, it is necessary that the administrator of this mechanism must be able to identify the production opportunities of the society with certainty. However, many of

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*This conclusion can be asserted with greater conviction if the cost functions of the resource owners who are involved in the externality situation are non-separable than if these cost functions are separable. See Davis and Whinston (31).

**An iterative procedure which can perform this function in at least some externality situations is described in Davis and Whinston (32), pp. 312-216.

***Davis and Whinston (31), p. 256 and p. 261.

the characteristics of the environment which influence most significantly the specification of the appropriate structure of any internalization mechanism which attempts to achieve this resource allocation are inherently stochastic in nature. Rainfall and, hence, stream flows exhibit both seasonal and annual variability. Similarly, the incidence of atmospheric inversions varies over time.* Consequently, any internalization mechanism which strives to exert optimal control over the production of an externality which embodies stochastic characteristics must be dynamically responsive to these stochastic environmental conditions. Thus, for example, if a taxation mechanism is to achieve the socially optimal generation of air pollution, the rate at which this tax is imposed upon the emitters of pollution must be increased as the marginal damages which are attributable to air pollution increase when an atmospheric inversion occurs; while if this same objective is to be attained through the application of performance standards to the generation of air pollution by these emitters, the restrictiveness of these standards must be increased in the event of an atmospheric inversion.

Obviously, the successful implementation of any dynamically responsive internalization mechanism requires both accurate predictions of those stochastic conditions which influence the optimal structure of this mechanism and perfect knowledge of the effect of these stochastic environmental conditions upon the value of the marginal damages which are attributable to the externality whose control is sought. Unfortunately, these requirements commonly fail to be fulfilled in those externality situations which are generally considered to constitute valid areas of governmental intervention, The general inability of physical scientists to forecast accurately future environmental conditions is well documented. In addition, their knowledge of the manner in which biological and chemical processes translate changes in basic environmental conditions into impacts which affect the production and consumption opportunities of society is surprisingly limited. Finally, the ability of social scientists to evaluate the value of the marginal damages which are incurred by society as a result of these impacts is severely circumscribed, both theoretically and in practice.**

The implications of these uncertainties for the development of internalization mechanisms is intensified by the realization that environmental systems can be imperfectly reversible. Toxic substances which

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*Roberts (93), p. 14 and p. 21.
**Roberts (93), pp. 20-28.

have been introduced into the environment may deteriorate extremely slowly and may be removable only imperfectly and at great cost. Reclamation of stripmined land is, at best, partial and, frequently, extremely expensive. The existence of limitations upon the reversibility of natural systems reduces the social desirability of utilizing any iterative technique to determine the optimal structure of any internalization mechanism, since it may be impossible to correct fully any inappropriate adjustment which is generated by that technique. Conversely, it enhances the desirability of developing internalization mechanisms which are "...designed to preserve options and avoid risks."* Therefore, in those externality situations in which either the probability that an irreversible impact will be generated is high or the anticipated consequences of any irreversible impacts which might be generated are especially adverse, it might be socially desirable to attempt to internalize these externalities through the initiation of either the direct governmental regulation of those activities which contribute to the creation of the potentially irreversible impacts or the imposition upon these activities of standards which specify the maximum allowable rate at which they may generate these externalities.

Yet, if either of these internalization mechanisms is adopted in any particular situation, it is important to recognize that compliance with its stipulations by those activities which are involved in the situation will not be automatic. Consequently, to induce compliance with the regulations or standards, some penalty must be imposed upon any activity which fails to comply with their stipulations. In general, the magnitude of this penalty should be relatively larger for the production of impacts for which the probability of irreversibility is relatively higher or the anticipated consequences of irreversible impacts are relatively more adverse. Moreover, since, for any reasonable penalty of a constant amount, there will exist instances in which some activities will rationally choose to violate these stipulations, it usually will be desirable to attempt to restrict the extent to which the actual generation of adverse effects exceeds the administratively specified levels by imposing upon those activities which violate any regulations or standards a positive marginal penalty for each unit by which the regulation or standard is violated. Similarly, since normal regulation and standards provide no incentives for activities to generate adverse external effects at rates which are lower than the rates which are specified in

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*Roberts (93), p. 22.

these regulations or standards, it might be socially desirable in many instances to attempt to induce the adoption of this behavior pattern by imposing a tax of a specified amount for each unit of the external effect which is produced up to the stipulated level (or by providing a subsidy of a specified amount for each unit of the external effect which is not produced relative to the stipulated level) in addition to any penalty which is imposed for violation of the regulation or standard. Thus, in summary, in externality situations which may involve the production of irreversible impacts, the best available internalization mechanism may consist of a positive marginal tax or subsidy applied to each unit of the externality which is produced up to a stipulated level, a substantial constant penalty for any production of the externality in excess of this stipulated level, and a positive marginal penalty applied to each unit of the externality which is produced in excess of the stipulated level.*

4.1.3 Synthesis

The numerous and varied proposals which have been advanced for the adoption of particular internalization mechanisms in particular externality situations lead inevitably to the conclusion that there exists no single mechanism for the internalization of externalities which uniformly constitutes the socially most desirable internalization mechanism in all externality situations. Rather, the appropriate internalization mechanism for any particular externality situation can be determined only after a careful evaluation of the relative strengths and weaknesses of each available alternative internalization mechanism in that situation has been completed. For, as Coase asserts:

> "All solutions have costs and there is no reason to suppose that government regulation is called for simply because the problem is not well handled by the market or the firm. Satisfactory views on policy can only come from a patient study of how, in practice, the market, firms and governments handle the problem of harmful effects."**

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*The use of mixed internalization mechanisms of this type are advocated in Roberts (93), pp. 74-79.

**Coase (19), p. 17.

Yet, Davis and Kamien offer a specific recommendation concerning the appropriate method of performing this study. In particular, they assert:

> "The tools of cost-benefit analysis appear to provide the proper perspective. In a given situation, the policymaker should consider the problem and imagine the application of each of the alternative approaches to it. The principle of selection is simple. Each measure of policy (including that of doing nothing) will have costs and benefits associated with it. The policymaker should select that measure for implementation which produces the greatest net benefits*

Nevertheless, since the costs and benefits which are attributable to the adoption of any particular internalization mechanism differ both among resource owners and among externality situations, it is reasonable that a variety of different internalization mechanisms should exist simultaneously.

4.2 Public Goods

A pure public good is a good which is consumed collectively by all members of society in the sense that the consumption of the good by one individual does not reduce the satisfaction which can be obtained by any other individual from his consumption of the good. Since each unit of a pure public good can be consumed simultaneously by all members of society, the marginal value to society of any particular unit of this good will be equal to the sum of the marginal values which are attached to this unit of the good by all members of society. Therefore, to attain economic efficiency in the provision of a pure public good, society should expand its production of this good to that level of output at which this sum is equal to the marginal cost which must be incurred by society in producing an additional unit of the good. This societal decision rule can be expressed mathematically as:

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*Davis and Kamien (28), p. 86.

$$\sum_{j=1}^{s} MRS_i^j = MRT_i$$

where MRS_i^j = the marginal value which is attached to pure public good i by individual j (i.e., individual j's marginal rate of substitution for pure public good i);

MRT_i = the marginal cost to society of pure public good i (i.e., the marginal rate of transformation of pure public good i); and

s = the total number of members of society.*

Unless the production function of society exhibits increasing returns to scale, satisfaction of this condition will guarantee that society will produce each unit of the pure public good whose marginal value to society equals or exceeds its marginal cost to society and will refrain from producing each unit of the good whose marginal cost to society exceeds its marginal value to society. Thus, no modification of the rate of production of this good will provide incremental benefits to society which exceed the marginal cost to society of performing the modification,

Having determined the optimal rate of production of a pure public good, it is necessary to specify the optimal pattern of consumption of this good by the various members of society. The opportunity to consume any existing quantity of this good can be granted to additional members of society without affecting the satisfaction which is obtained from its consumption by those members of society who initially have been consuming the good. Therefore, any allocative mechanism which excludes any individual member of society from the consumption of any individual unit of the good will be economically inefficient because it will reduce the satisfaction of that member of society who is excluded from consumption without increasing the satisfaction of any other member of society. Even if it is practicable to exclude some members of society

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*See Samuelson (102) and Samuelson (99) for a mathematic derivation and a graphical derivation, respectively, of this optimality condition.

from the consumption of some units of a pure public good, performing this exclusion will he socially undesirable because the attainment of economic efficiency requires that all members of society must be granted free access to the consumption of all units of that good. Therefore, the socially optimal price which should be charged for the right to consume a pure public good is zero.

However, if a price of zero is charged for the right to consume each unit of a pure public good, some mechanism other than the price system must be employed to finance the provision of this good. Moreover, if the financing mechanism which ultimately is adopted is to promote unambiguously the attainment of economic efficiency, this mechanism must guarantee that each citizen's contribution to defray the cost of providing the pure public good does not exceed the value of the total benefits obtained by that citizen from his consumption of the good. Unless this condition is satisfied, one or more members of society will suffer a decrease in their satisfaction as a result of the provision of the pure public good. Yet, at the socially optimal level of total production of this good, the value of the marginal benefit which is obtained by society from each unit of the good which is provided must equal or exceed the marginal cost which is incurred by society in providing that unit of the good. Therefore, the value of the total benefit which is obtained by society from the provision of the socially optimal quantity of the good must equal or exceed the total cost which is incurred by society in providing this quantity of the good. Consequently, there must exist at least one financing mechanism for which this distributional provision will be fulfilled. In fact, it generally will be possible to satisfy this condition with an infinite number of alternative financing mechanisms which are differentiated solely by the relative magnitudes of the values of the net benefits which are obtained by the various members of society.

4.2.1 The Inefficiency of Decentralized Provision of Public Goods

Since the consumption of a pure public good by any individual does not diminish the satisfaction which other individuals can obtain from their consumption of the good and since it is economically inefficient, if not impossible, to exclude any individual from the consumption of the good, it is theoretically impossible for a decentralized market mechanism to induce the economically efficient provision of a pure public good. In particular, when these circumstances prevail, each citizen's consumption of the existing quantity of the good will be totally

independent of the magnitude of his contribution to the financing of the cost of providing the good. Moreover, if the population of the society is sufficiently large that the value of the benefits which any particular citizen obtains from his consumption of this good represents an insignificant portion of the value of the total benefits which are obtained by all members of society from their consumption of the good, a decision by any particular citizen to refrain to any extent from contributing toward the provision of the good will have no noticeable effect upon either the total quantity of the good which is available for consumption or, consequently, the total satisfaction which this citizen obtains from his consumption of the good. Therefore, it will be individually rational for each member of society to volunteer to contribute toward the provision of any particular quantity of a pure public good an amount of income which is substantially less than the maximum amount which he ultimately would be willing to surrender in exchange for the provision of that quantity of the good. Yet, if each member of society adopts this individually rational behavior pattern, the cumulative result of these independent, decentralized actions will be the provision of an economically inefficiently small quantity of the good.

Moreover, if the society initially achieves an equilibrium in which an inefficiently small quantity of a pure public good is produced, any individual citizen who independently attempts to rectify this inefficiency will be required to finance the entire marginal cost of any incremental production of the good which he provides; while he will obtain only an insignificant portion of the value of the marginal benefits which are obtained by all members of society as a result of this expansion of production. Consequently, it is extremely unlikely that independent, decentralized action will successfully increase the production of any pure public good from any inefficiently low initial equilibrium level to the economically efficient level of output.

Therefore, it can reasonably be concluded that independent, decentralized decision-making is generally incapable of achieving the economically efficient provision of a pure public good. Instead, it is virtually inevitable that it will be necessary to rely upon some centralized resource allocation mechanism to promote the production of the most socially desirable quantity of any good of this type.

4.2.2 The Centralized Provision of Public Goods

Any system of lump-sum taxes which requires each member of society to contribute toward the provision of a pure public good an

amount of income or wealth which does not exceed the value of the benefits which this individual obtains from his consumption of that good will constitute an economically efficient mechanism to finance the provision of the good. Moreover, only if the value of the total benefits which are obtained by all members of society from their consumption of the good is identically equal to the total cost to society of providing this good will there exist only one system of lump-sum taxes which will meet these specifications. Thus, in general, if the provision of a pure public good is potentially socially desirable (i.e., if total societal costs do not exceed the value of total societal benefits), there will exist an infinite number of economically efficient systems of lump-sum taxes to finance the provision of this good.

Unfortunately, the accurate specification of any of these economically efficient taxation systems requires detailed knowledge of the willingness of each member of society to pay for the provision of the good. In the absence of governmental omniscience, this specific information can only be obtained by consulting those members of society. However, these individuals almost invariably will realize that their revelation of this knowledge can and will be used as the basis for the imposition of a tax upon them. Therefore, they rationally will understate their willingness to pay for the provision of the good, since they will be able to consume the entire available quantity of the good regardless of the extent to which they contribute to the financing of the cost of its provision.

Consequently, the government will be obliged to rely upon imperfect estimates of the willingness of these citizens to pay for the provision of the public good as the primary basis for the development of any system of lump-sum taxes. Hence, in general, the tax systems which actually are implemented to finance the provision of pure public goods will not constitute economically efficient mechanisms for achieving this objective. The ultimate consequences of this theoretical impossibility of obtaining accurate information concerning the preferences of each member of society relative to the provision of a pure public good include not only the inability of government to identify an economically efficient taxation mechanism to finance the provision of this good, but also the incapacity of the public sector to determine the most socially desirable quantity of the good to provide.

These theoretical difficulties are compounded by the practical problem that the taxation mechanisms which actually are available for implementation by the government do not include the neutral lump-sum

taxes which are required for the attainment of economic efficiency. Although, in theory, it is possible to develop a pure income tax or a pure wealth tax which is functionally equivalent to any particular lump-sum tax, the available income and wealth taxes which actually can be employed to finance the provision of public services incorporate variable marginal tax rates and multiple exemptions from taxation which inevitably distort the allocation of resources which is achieved at equilibrium.

Thus, although the conceptual specification of the conditions which must be satisfied to guarantee the attainment of economic efficiency in the provision of a pure public good is a relatively simple exercise, the development and implementation of mechanisms to promote the fulfillment of these conditions encounter numerous practical and theoretical difficulties. Yet, somewhat paradoxically, the failure of the attributes of most of the goods and services which actually are provided by the public sector to conform perfectly to the attributes which are characteristic of pure public goods may, in many instances, enhance the ability of the government to promote the attainment of economic efficiency in the provision of those goods and services which it actually provides.

4.2.3 Exclusion and the Centralized Provision of Public Goods

Recognizing the serious theoretical and practical difficulties which hinder, if not preclude, the fulfillment of the theoretical conditions for the attainment of economic efficiency in the provision and financing of public goods, numerous researchers* have asserted that in many of those situations in which it is possible to some extent to exclude specific members of society from the consumption of a public good, it may be socially desirable to charge a positive price for the consumption of this good. Admittedly, the adoption of a pricing policy of this type for any public good will restrict society to the attainment of an economically inefficient pattern of consumption of the good at equilibrium. Specifically, this pricing policy will exclude some members of society from the consumption of some units of this good; and, theoretically, it is economically inefficient to exclude any member of

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*The exchange of ideas contained in Buchanan (14), Minasian (75), Minasian (76), Samuelson (98), Samuelson (100), and Samuelson (101), comprises a thorough analysis of this assertion. In addition, McKean and Minasian (71) provides an excellent summary of this issue.

society from the consumption of any unit of a public good because this exclusion will deny to that individual a net benefit whose provision imposes no cost upon any other member of society. However, this pricing policy also has the offsetting virtue that it directly provides objective information concerning the minimum amount of income which members of society are willing to surrender in exchange for the right to consume the public good. This information, which clearly reflects the cost of employing society's scarce resources in alternative uses, constitutes a valuable input into the determination of the most socially desirable quantity of the public good for the government to provide. Thus, shifting from a policy of permitting free access to a public good to all members of society to a policy of charging each member of society a positive price for the consumption of this good can produce an increase in the extent to which economic efficiency is attained in the production of the good, in exchange for a decrease in the extent to which economic efficiency is attained in the consumption of the good.

However, this shift in policy will be effective in producing these effects only if it is possible to exclude from the consumption of the good those individuals who refuse to pay the price which is charged for the good. Yet, for a surprisingly large number of public goods, it is technologically possible to enforce some degree of exclusion from the consumption of the good upon any particular member of society. For example, even in a community which experiences widespread air pollution, it is possible to exclude some residents from the benefits of an air pollution control program merely by imposing less restrictive controls upon emitters of air pollution who are located near to these residents than the controls which are imposed upon emitters who are located at a substantial distance from these residents. Thus, even within the context of achieving a specified reduction in the total emission of air pollutants, it is possible for the government to exercise substantial control over the distribution of the benefits from this reduction in air pollution among the various residents of the community.

However, a demonstration of the technological feasibility of excluding certain individuals from the consumption of a public good does not constitute a demonstration of the social desirability of adopting a pricing policy which is capable of performing this exclusion. The costs of developing, administering, and enforcing this pricing policy may greatly exceed the net benefits which are obtained by society from the impacts which this pricing policy exerts upon the provision and consumption of this public good.

4.2.4 Synthesis

Charging a positive price for the consumption of a public good necessarily restrains society from the attainment of economic efficiency in the consumption of goods and services. Moreover, the design and implementation of a mechanism to administer a positive pricing policy may require the incurring of substantial cost by society. Conversely, the charging of a zero price for the consumption of a public good virtually precludes the attainment of economic efficiency in the production of that good, in particular, and all goods and services, in general. Consequently, for any public good, the determination of the social desirability of charging any particular price for the consumption of the good should be based upon a thorough comparison of the costs which will be incurred by society and the benefits which will be obtained by society if this pricing policy is adopted.

4.3 Increasing Returns to Scale

A production process exhibits increasing returns to scale if equal proportional increases in the utilization rates of all inputs into this process generate a greater proportional increase in the production rate of the output of the process. Thus, if the firm which operates this production process purchases its inputs in perfectly competitive markets at constant prices (or, at least, if input prices do not increase sufficiently rapidly as the firm expands its production to more than offset the increasing returns to scale), any particular proportional increase in production cost will generate a greater proportional increase in output and, hence, the average cost of producing this output will decrease as output expands. Moreover, since marginal cost must be less than average cost whenever average cost is decreasing, marginal cost must be less than average cost whenever increasing returns to scale prevail in a production process. These relationships are represented graphically in Figure 4.1, which illustrates the cost conditions which confront a firm whose production process exhibits increasing returns to scale for all feasible rates of production. In this diagram, the curve labelled AC represents the average cost which the firm must incur at each rate of production; while the curve labelled MC describes the marginal cost which is absorbed by the firm at each level of output. It is generally asserted that cost conditions of this type will exist in any enterprise whose production process requires both the incurring of substantial fixed costs before any output can be produced and, subsequently, the

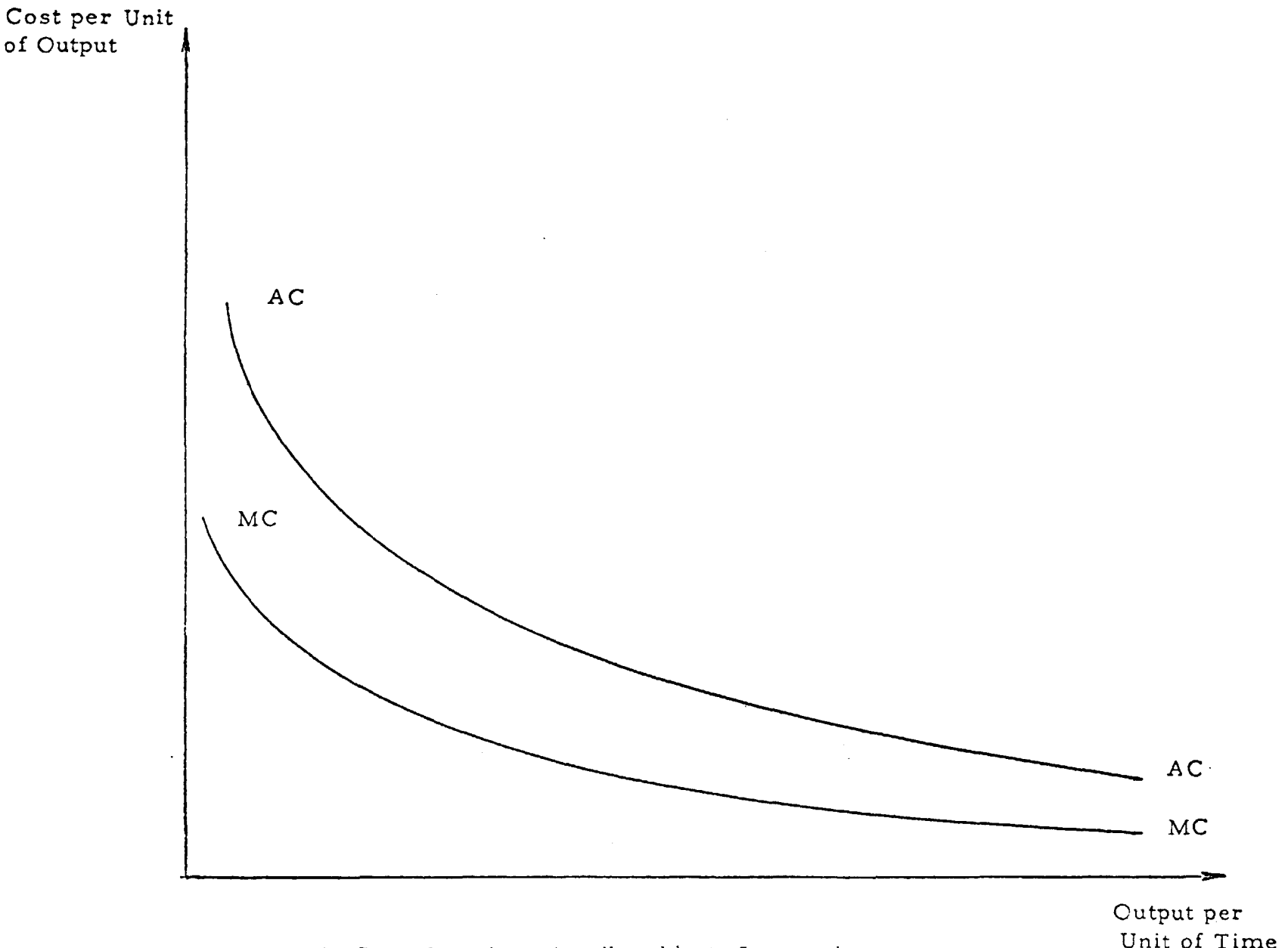

Figure 4.1 Cost Functions Attributable to Increasing Returns to Scale

absorbing of only insignificant incremental cost as output is expanded. Thus, the cost curves in Figure 4.1 might reasonably well describe the cost conditions which confront the electricity generation industry, the natural gas industry, urban mass transit, or, more importantly for the purposes of this report, the provisions of municipal water and sewerage services.

4.3.1 The Impossibility of Perfect Competition

Whenever cost conditions of this type confront all of the firms in a perfectly competitive industry throughout all relevant ranges of output, it is theoretically impossible for perfect competition to prevail in this industry when equilibrium is attained, When perfectly competitive market conditions exist in an industry, each firm in that industry will be unable to exert any noticeable influence over the prevailing market price solely on the basis of its own output decisions. Therefore, each of these firms will rationally consider this price to be a constant. Then, in attempting to maximize its profits, each firm will choose to produce its output at that rate for which price is equal to marginal cost. This situation is illustrated in Figure 4.2, where the firm initially chooses to produce the output Q_o when the prevailing market price is P_o. However, when increasing returns to scale exist for the firm, the average cost of production, AC_o, will exceed the prevailing market price (i. e., the average revenue from production) at this output level; and, hence, the firm will incur a loss of $(AC_o - P_o)$ on every unit of output which it produces, Moreover, for each unit of output which the firm produces in excess of Q_o, price will exceed marginal cost. Thus, the firm can decrease its losses by expanding its output indefinitely beyond Q_o. In fact, at production rates in excess of Q_1, the firm can actually earn positive profits. However, if each firm in the industry adopts this production strategy the prevailing market price will decline and, once again, all firms in the industry will be incurring losses. Conceivably, this process could continue until each firm in the industry is producing an infinite level of output at a market price of zero. More realistically, however, as industry output expands and market price declines, increasingly large numbers of firms will choose to leave the industry until, at the limit, only one firm -- a natural monopoly -- remains. Moreover, this outcome constitutes a necessary condition for the attainment of an economically efficient allocation of resources in any industry in which increasing returns to scale exist at equilibrium. For any level of output, a higher average cost of production will be incurred by the industry if more than one firm produces this output than if this total output is produced solely by one firm (e. g., in the

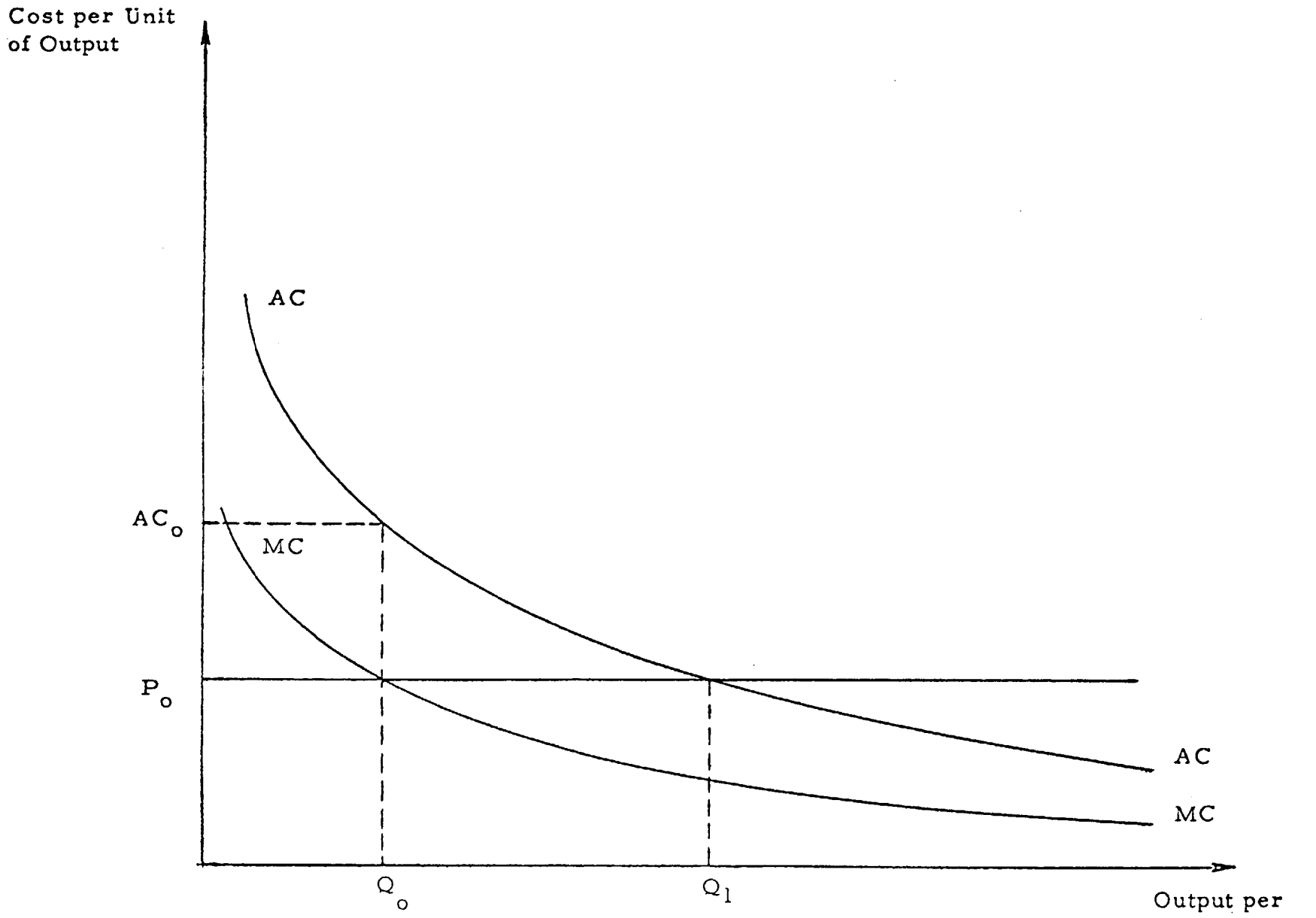

Figure 4.2 Perfect Competition Under Increasing Returns to Scale

context of Figure 4.2, the average cost of production in the industry will be lower if one firm produces the output Q_o than if two firms each produce the output $Q_o/2$}. Thus, society will be required to sacrifice more alternative goods and services to obtain any particular level of output in a naturally monopolistic industry if it attempts to maintain some degree of competition in this industry instead of permitting only one firm to produce this output at equilibrium.

4.3.2 The Inefficiency of Unregulated Monopoly

Yet, if society decides to permit a single firm to monopolize the production of this output, it generally will be socially desirable for the government to initiate policies which will control the tendencies of an unregulated monopolist to allocate resources in an economically inefficient manner. Since a monopolist directly confronts the actual market demand curve for his output, he can be expected to both recognize and take advantage of the effect which his production decisions have on the market price which prevails for his product, Therefore, if the monopolist desires to maximize profits, he will choose to produce the restricted output level for which marginal revenue is equal to marginal cost instead of the economically efficient output level for which price is equal to marginal cost. This situation is illustrated in Figure 4.3, where the curve labelled D represents the market demand curve for the industry's output and the curve labelled MR depicts the marginal revenue curve which is associated with this demand curve. Confronted with these market opportunities, an unregulated profit-maximizing monopolist will choose to produce the output Q_m, for which the market will pay a price P_m. However , as is indicated by the relative heights of the demand curve and the marginal cost curve, at this level of output some member or members of society are willing to pay substantially more for an additional unit of output than the cost which must be incurred by society in producing this unit of output. Consequently, it is socially desirable to produce at least one more unit of this product. In addition, if no income effects influence the demand for this product, the social desirability of expanding production will continue to exist until output has increased to the level Q, at which the maximum amount that some individual is willing to pay for an additional unit of the product (i.e., the height of the demand curve) is identically equal to the cost to society or producing this unit (i.e., the height of the

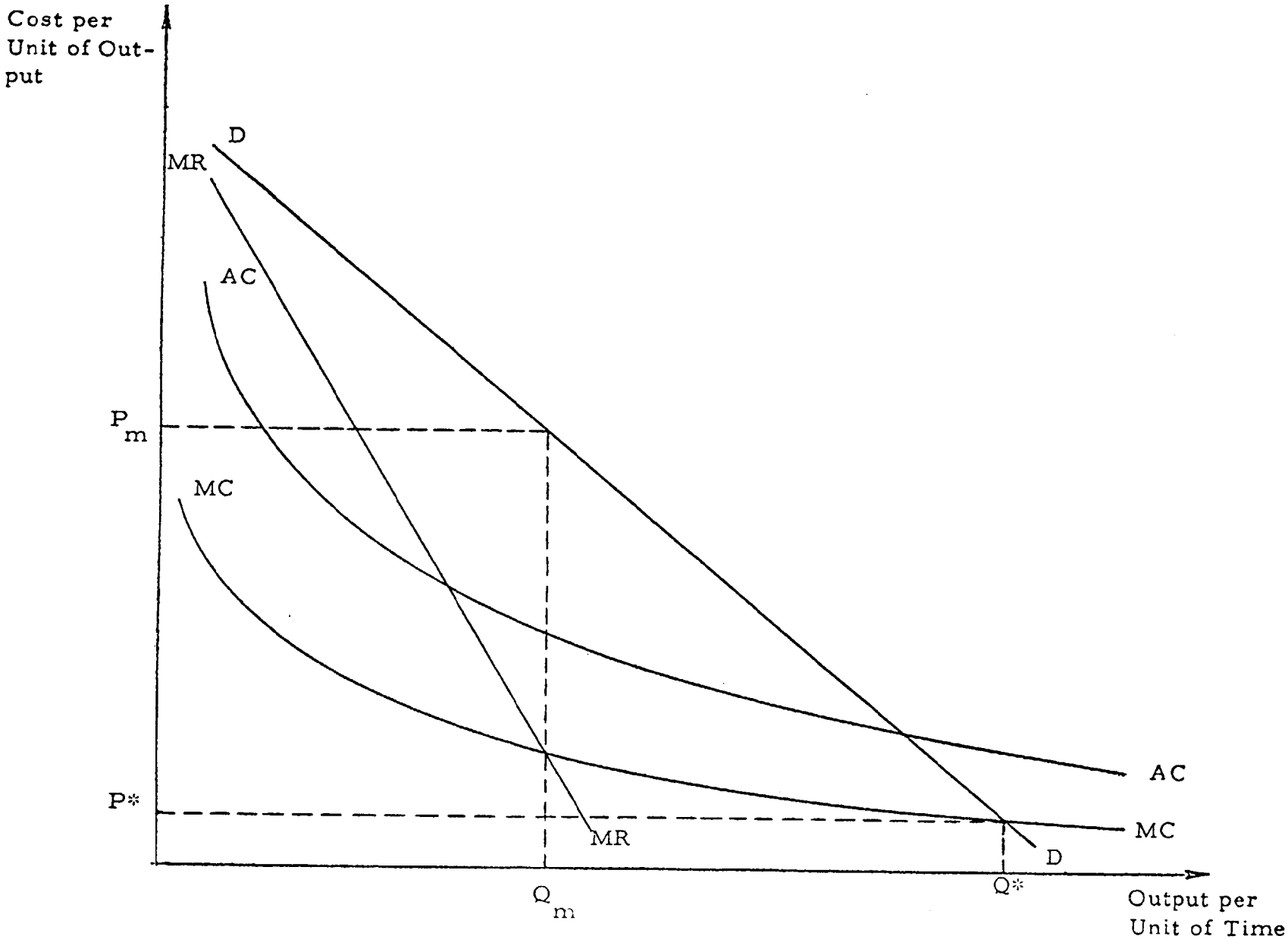

Figure 4.3 Unregulated Monopoly Under Increasing Returns to Scale

marginal cost curve). Thus, without regulation, a profit-maximizing monopolist can be expected to produce an economically inefficiently low level of output for which he receives an economically inefficiently high price.

4.3.3 Optimal Regulation of Natural Monopoly

Theoretically, the socially optimal public policy to correct this misallocation of resources consists of, first, requiring the natural monopolist to produce as many units of output as the members of society are willing to purchase at the price which is determined by the intersection of the market demand curve and the monopolist's marginal cost curve (P*) and, then, paying to the monopolist a subsidy which will fully compensate him for the loss which he would have incurred if he had sold the output Q* at the price P* in the absence of any governmental action. This policy is illustrated in Figure 4. 4, where the shaded area indicates the magnitude of the subsidy which must be provided to thd natural monopolist. Moreover, if the implementation of this policy is to promote the attainment of economic efficiency (i,e., to increase the satisfaction of at least one member of society without decreasing the satisfaction of any other member of society), this subsidy must be financed through a system of lump-sum taxes which collects from each consumer of this product an amount of income which does not exceed the difference between the value of the benefit which he obtains from his consumption of the product and the amount of income which he has been required to pay to obtain the units of output which he consumes (i.e., an amount of income which does not exceed his consumer's surplus from the consumption of the product). If a subsidy of this type cannot be implemented, the total benefits which society obtains from the production and consumption of this product must be less than the total cost which society incurs in producing the product and, hence., the product should not be produced. Thus, only if the subsidy can be financed in an economically efficient manner through the imposition of lump-sum taxes upon the consumers of the product will the production of this product constitute a socially desirable activity.

4.3.4 Practical Regulation of Natural Monopoly

It is relatively simple to specify the theoretically optimal taxation policy to finance the provision of an economically efficient subsidy to a natural monopoly. However, the implementation of a specific system of lump-sum taxes which is consistent with this optimal policy

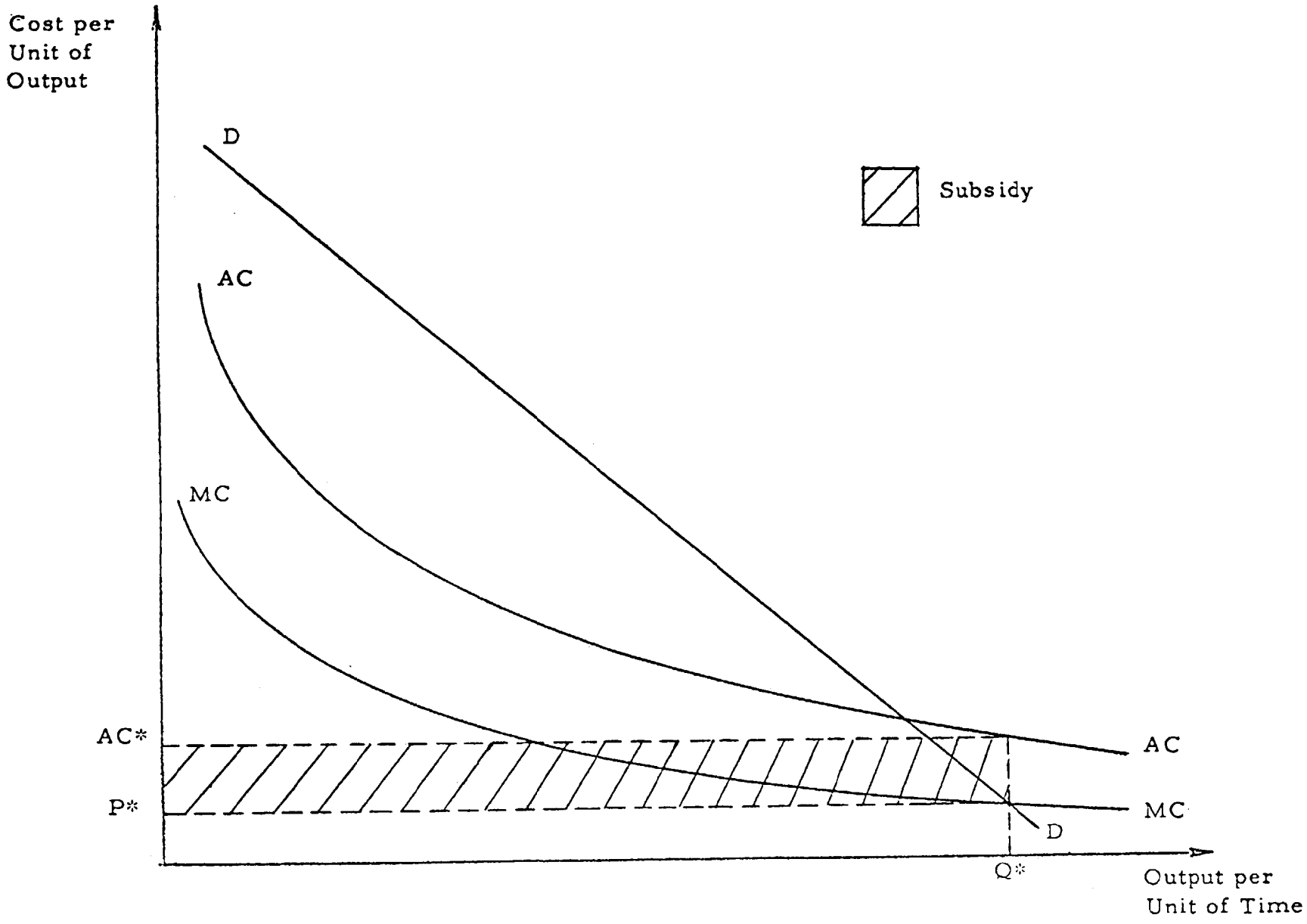

Figure 4.4 Optimally Regulated Monopoly Under Increasing Returns to Scale

requires detailed knowledge of the willingness of the consumers of the output of the natural monopoly to pay for this output. Yet, in the absence of omniscience, governmental regulatory agencies will be unable to obtain this information without consulting these consumers. Moreover, recognizing that the revelation of this knowledge can and will be utilized as the basis for the imposition of a tax upon them, these consumers rationally will be unwilling to provide this information to the regulatory agencies. Consequently, these agencies will be forced to rely upon imperfect forecasts of the willingness of these consumers to pay for the output of the natural monopoly as the primary basis for the development of their taxation policies. Hence, these policies will not necessarily constitute economically efficient mechanisms for the regulation of natural monopolies. In addition, the taxation mechanisms which are actually available for implementation by the regulatory agencies do not include the neutral lump-sum taxes which are required for the attainment of economic efficiency. Rather, they consist of income and wealth taxes with variable marginal tax rates whose application inevitably distorts the allocation of resources which is achieved at equilibrium.* Thus, the possibility arises that, in practice, a theoretically inferior policy for the regulation of natural monopolies will generate an allocation of resources at equilibrium which is more socially desirable than the equilibrium resource allocation which is produced by the theoretically optimal policy.

In particular, it is conceivable that, in some instances, the standard regulatory policy of requiring the natural monopolist to produce as many units of output as the members of society are willing to purchase at the price which is determined by the intersection of the market demand curve and the monopolist's average cost curve will be socially superior to the theoretically optimal regulatory policy. This standard regulatory policy is illustrated in Figure 4.5, where the price established by the regulatory agency is labelled P_r and the quantity which the natural monopolist produces at this price is labelled Q_r. This policy does have the virtue of guaranteeing the natural monopolist a normal return on his investment (i.e., zero economic profits) without providing any direct subsidy to him. However, it also has the weakness of producing an economically inefficient allocation of resources

*For a thorough discussion of these practical difficulties in regulation, see Vickrey (112).

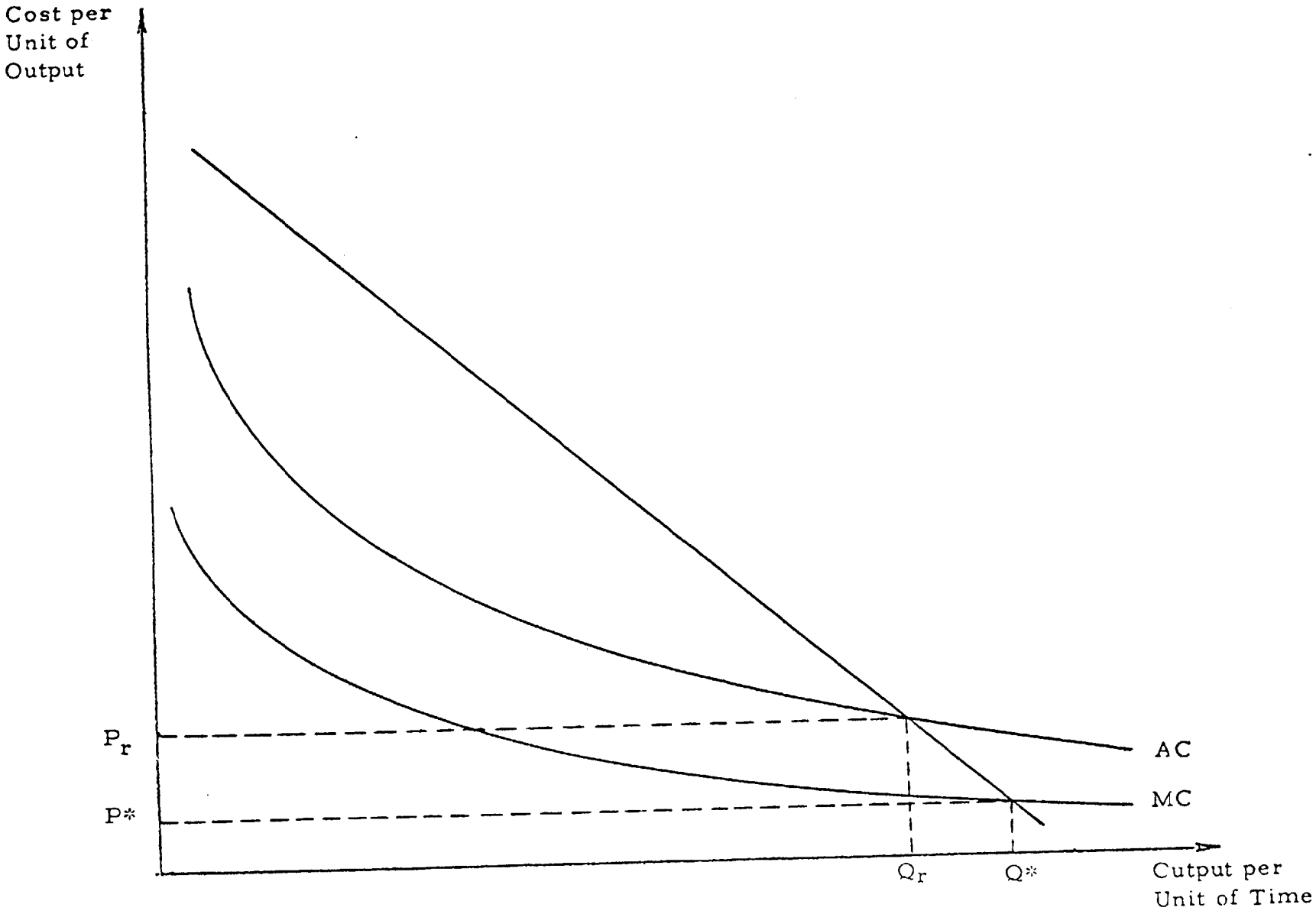

Figure 4.5 Standard Regulation of Monopoly Under Increasing Returns to Scale

at equilibrium since, at this equilibrium, price exceeds marginal cost and, hence, output can be expanded at a cost to society which is less than the value of the benefits which are obtained by the consumers of the additional output. In addition, the implementation of this policy incorporates data manipulation problems, especially with respect to the measurement and allocation of elements of fixed cost, which almost unavoidably cause the price which actually is established by the regulatory agency to deviate from the price which corresponds to the intersection of the market demand curve and the natural monopolist's average cost curve. Thus, this standard regulatory policy will not be uniformly most socially desirable in all situations which are characterized by increasing returns to scale.

Recognizing these weaknesses of both the theoretically optimal regulatory policy and the standard regulatory policy, Coase* suggests that in many natural monopoly situations socially superior allocations of resources will be achieved if multi-part pricing policies are established. In particular, Coase recommends that each consumer of the output of a natural monopoly should be required to pay at least a two-part price in which the first part is independent of the quantity of output which he purchases and reflects the direct cost of providing any level of service to him and the second part is directly dependent upon the quantity of output which he purchases and reflects the marginal cost of supplying an additional unit of output to him. For example, in the context of the provision of municipal water and sewerage service, an appropriate two-part pricing mechanism would consist of both a charge for connection to the municipal water and sewerage system which reflects the direct cost of providing this connection and a charge for each unit of water or sewerage service utilized by the consumer which reflects the marginal cost of providing this water or sewerage service. If the charge for connection to the system is set correctly, it should impose higher costs upon those potential development sites to which it is relatively expensive to provide water and sewerage service (i. e., relatively remote sites) than upon those potential development sites which are relatively inexpensive to serve. A connection charge of this type should encourage the development of land use patterns which economize on the use of resources in the provision of water and sewerage services. In addition, to the extent that the costs

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*Coase (20).

of providing water and sewerage services are positively correlated with the cost of providing water and sewerage service, this two-part pricing policy should encourage the development of land use patterns which economize on the use of resources in the provision of these other municipal services. Moreover, to the extent that the two component charges in this policy are designed to recover the total direct cost of providing the naturally monopolistic output, the ability of this policy to generate revenues which are sufficient to recover this cost will constitute a strong market test of the social desirability of producing this output. No direct test of this type exists for the theoretically optimal policy. However, the cost of developing and administering a multi-part pricing policy may be substantial and the allocation of resources which is achieved by this policy at equilibrium may be less socially desirable that the resource allocation which is generated, in practice, by the theoretically optimal policy, Therefore, it is impossible to conclude a priori that multi-part pricing is the most socially desirable policy for the regulation of natural monopoly in all situations.

4.3.5 Synthesis

It is impossible to conclude that any single public policy constitutes the socially optimal policy for the regulation of all situations which incorporate increasing returns to scale. Rather, in each situation it is necessary to compare the relative advantages and disadvantages of all potentially applicable policies before selecting any specific policy for implementation. Once again, cost-benefit analysis appears to provide the most appropriate framework within which to conduct this comparison and, subsequently, to choose that alternative policy which can be expected to provide the greatest net benefit to society.

4.4 Conclusion

The essence of economic theory is the analysis of tradeoffs. The concepts presented in this chapter clearly demonstrate that this analysis is applicable not only to the determination by the consumer of his utility maximizing bundle of commodities or the specification by the firm of its profit-maximizing combination of inputs and outputs, but also to the selection by the government of the most socially desirable set of policy instruments for the rectification of market situations which involve externalities public goods, or increasing returns to scale.

There exists no single public policy which is uniformly most socially desirable in the control of any of these three types of market failure. Rather, in any particular situation of any of these types, the most socially desirable public policy can be determined only on the basis of a careful comparison of the relative advantages and disadvantages of the various alternative policies which actually are available for adoption.

Nevertheless, there does exist a single analytical framework which is universally appropriate for the comparison of the strengths and weaknesses of alternative policies. This analytical framework is cost-benefit analysis, in which, first, the costs and benefits associated with the adoption of each alternative policy are enumerated and evaluated and, then, that policy which exhibits the greatest difference between total benefits and total costs is recommended for implementation.